Chemistry Practice Paper - Answers and Marking Scheme

Level: Secondary 6 | Subject: Chemistry | Time allowed: 75 minutes | Total marks: 100 | Number of questions: 24

Part 1. Nomenclature and Isomerism of Organic Compounds (16 marks)

Show all working or draw the structure. Give units in every answer.

#	Question	Answer and marking notes
1	How many structural isomers does the alkane with molecular formula C5H12 have? Name each isomer. **[4 marks]**	Three: pentane, 2-methylbutane and 2,2-dimethylpropane.
2	Give the systematic name of (CH3)2CHCH2CH3 and state the number of carbon atoms in its principal chain. **[4 marks]**	The longest chain has four carbon atoms, so the name is 2-methylbutane.
3	How many geometric isomers does but-2-ene have? Explain why geometric isomerism arises. **[4 marks]**	Two (cis and trans). A carbon-carbon double bond cannot rotate freely, so the two substituents on the double bond may lie on the same side or on opposite sides.
4	Styrene is the monomer of polystyrene. Write the condensed structural formula of styrene and state how addition polymerisation differs from condensation polymerisation in terms of by-products. **[4 marks]**	Styrene is C6H5CH=CH2. Addition polymerisation produces no small-molecule by-product, whereas condensation polymerisation loses a small molecule such as water for each bond formed.

Part 2. Esterification, Saponification and Fats (16 marks)

Relative atomic masses: H 1.0, C 12.0, O 16.0, K 39.0.

#	Question	Answer and marking notes
1	With concentrated sulphuric acid as catalyst, 46.0 g of ethanol reacts with excess ethanoic acid. Assuming complete reaction, calculate the theoretical mass of ethyl ethanoate. **[4 marks]**	Moles of ethanol = 46.0 / 46.0 = 1.00 mol; molar mass of ethyl ethanoate = 88.0 g/mol; theoretical mass = 88.0 g.
2	100 g of a fat is completely saponified and consumes 0.300 mol of potassium hydroxide. Calculate the saponification value in mg of KOH per gram of fat. **[4 marks]**	Mass of KOH = 0.300 x 56.0 = 16.8 g = 16800 mg; saponification value = 16800 / 100 = 168 mg/g.
3	Name the two reactants and the two products of the saponification of a fat. **[4 marks]**	Reactants: a fat (triglyceride) and sodium hydroxide solution. Products: sodium salts of fatty acids (soap) and glycerol.
4	Explain the purpose of heating during saponification and the purpose of adding common salt afterwards. **[4 marks]**	Heating raises the reaction rate and melts the fat so that it contacts the alkali better. Adding salt causes salting out: the solubility of soap falls, so soap separates from the glycerol solution.

Part 3. Electrolysis, Electroplating and Electrochemical Cells (18 marks)

Faraday constant = 96500 C/mol.

#	Question	Answer and marking notes
1	A current of 2.00 A passes through copper(II) sulphate solution for 1930 s. Calculate the mass of copper deposited at the cathode. (Cu = 63.5) **[4 marks]**	Charge = 2.00 x 1930 = 3860 C; moles of electrons = 3860 / 96500 = 0.0400 mol; moles of copper = 0.0200 mol; mass = 0.0200 x 63.5 = 1.27 g.

2	Silver is electroplated onto a metal spoon using a current of 5.00 A. Calculate the time needed to deposit 10.8 g of silver, giving the answer in minutes. (Ag = 108) **[5 marks]**	Moles of silver = 10.8 / 108 = 0.100 mol; charge = 0.100 x 96500 = 9650 C; time = 9650 / 5.00 = 1930 s = 32.2 minutes.
3	In acidic solution MnO4- is reduced to Mn2+. Write the half-equation and state the number of moles of electrons transferred per mole of MnO4-. **[4 marks]**	MnO4- + 8H+ + 5e- gives Mn2+ + 4H2O; five moles of electrons are transferred per mole of MnO4-.
4	For a zinc-copper cell, E(Zn2+/Zn) = -0.76 V and E(Cu2+/Cu) = +0.34 V. Calculate the standard cell e.m.f. and state which metal is the anode during discharge. **[5 marks]**	Standard e.m.f. = 0.34 - (-0.76) = 1.10 V; zinc is the anode (oxidised) and copper is the cathode (reduced).

Part 4. Chemical Equilibrium (18 marks)

All concentrations are in mol/dm3 and the temperature is constant.

#	Question	Answer and marking notes
1	In a 1.0 dm3 vessel, 1.00 mol of hydrogen reacts with 1.00 mol of iodine vapour. At equilibrium 1.56 mol of hydrogen iodide is present. Calculate Kc at that temperature. **[5 marks]**	Forming 1.56 mol of HI uses 0.780 mol of each reactant, so [H2] = [I2] = 0.220 mol/dm3 and [HI] = 1.56 mol/dm3; Kc = 1.56 squared / (0.220 x 0.220) = 50.3.
2	For the reaction in the previous question, would doubling the volume at constant temperature shift the position of equilibrium? Explain. **[4 marks]**	No shift. The number of moles of gas is the same on both sides; doubling the volume lowers every concentration in the same proportion, so Qc remains equal to Kc.
3	State the general form of an equilibrium constant Kc and explain why pure solids do not appear in the expression. **[4 marks]**	Kc is the product of product concentrations each raised to its stoichiometric number, divided by the same product for the reactants. The concentration of a pure solid is constant at fixed temperature and is absorbed into Kc.
4	For 2SO2(g) + O2(g) reversible 2SO3(g), Kc = 280 dm3/mol at a certain temperature. At equilibrium [SO2] = 0.100 mol/dm3 and [SO3] = 0.500 mol/dm3. Calculate [O2]. **[5 marks]**	Kc = [SO3] squared / ([SO2] squared x [O2]), so 280 = 0.250 / (0.0100 x [O2]) and [O2] = 0.0893 mol/dm3.

Part 5. Industrial Chemistry and Yield (16 marks)

Give percentage yields to three significant figures.

#	Question	Answer and marking notes
1	In the Haber process 6.00 g of hydrogen reacts with excess nitrogen. The theoretical mass of ammonia is 34.0 g but only 27.2 g is obtained. Calculate the percentage yield. **[4 marks]**	Percentage yield = 27.2 / 34.0 x 100% = 80.0%.
2	In the Contact process, 3.20 g of sulphur is converted completely into sulphuric acid. Calculate the theoretical mass of sulphuric acid. (S = 32.0, H2SO4 = 98.0) **[4 marks]**	Moles of sulphur = 3.20 / 32.0 = 0.100 mol; the same number of moles of acid forms; mass = 0.100 x 98.0 = 9.80 g.
3	Ethene is hydrated to ethanol: C2H4 + H2O gives C2H5OH. Calculate the atom economy and justify it with molar masses. **[4 marks]**	Every atom of the reactants appears in the single product, so the atom economy is 100% (46.0 / (28.0 + 18.0) x 100% = 100%).

4	The Haber process operates at about 450 degrees Celsius and 200 atmospheres. Explain, in terms of rate and equilibrium, why a lower temperature is not used. **[4 marks]**	Ammonia synthesis is exothermic, so a low temperature favours the forward reaction; however the rate would be far too slow and equilibrium would take very long to reach, so 450 degrees Celsius is a compromise between rate and yield, used together with a catalyst.

Part 6. Polymers and Plastics Recycling (16 marks)

Answers must match the polymer structures and the recycling codes.

#	Question	Answer and marking notes
1	A sample of polyvinyl chloride has an average molecular mass of 62500. Calculate its degree of polymerisation. (Molar mass of the monomer C2H3Cl = 62.5 g/mol) **[4 marks]**	Degree of polymerisation = 62500 / 62.5 = 1000.
2	State the type of polymerisation for polyethylene and for nylon-6,6, and give one structural difference between their main chains. **[4 marks]**	Polyethylene is formed by addition polymerisation and its main chain contains only carbon atoms; nylon-6,6 is formed by condensation polymerisation and its main chain contains amide linkages with nitrogen atoms.
3	Write the condensed formula of the repeating unit of polystyrene and name its monomer. **[4 marks]**	The repeating unit is -CH(C6H5)-CH2- and the monomer is styrene.
4	In the plastics recycling coding system, what number is given to polyethylene terephthalate (PET)? State one major use of recycled PET. **[4 marks]**	PET carries recycling code 1; recycled PET is commonly made into polyester fibre for clothing and filling material.